GRAVITY FLOW VERTICAL FARMING USING
AQUAPHONIC SYSTEM

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Report submitted in partial fulfilment of the requirements
for the award of Bachelor of Mechanical Engineering

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JUNE 2013

ABSTRACT

This research was focused on demonstrating that vertical farming is an alternative solution to reduce environmental problem and lack of healthy food problem. The objective of the study is to design and fabricate vertical farming aquaponic system for home application. The main part of this study is to rear Red tilapia, grow vegetable and strawberry plants. It is also a way to show a method to plant the vegetable and rear aquatic animal at a safe place without endangering the people but at the same time give benefit to the mother earth. This research involved designing and fabrication of aquaponic. The vegetable was planted inside the basket of the pipe holes while the fish was kept in the fish tank. The type of bed grow is used was a curved tank located above the fish tank. The water from the fish tanks will be pumped to the grow bed. The water filtered by plant then will flow back to the fish tank. The design of the piping system consist of six pipes and each with a diameter of 100 mm and have seven holes drilled at equidistance. The water flow rate is 1.2408 x 10^{-3} m^3 /s from supply pump. There were also two curved tanks placed inside the aquaphonic house which used the floating polystyrenes planting system. The curved tanks are made of fiber glass that was fabricated and strengthened. A stress and strain analysis was done to the aquaphonic curve tank before and after reinforcement. As a result, the maximum displacement of the curve tank decreased after reinforcement process was done. The system was completed and installed.

ABSTRAK

Objektif kajian saya ialah untuk merekacipta dan menghasilkan tanaman menegak untuk kegunaan rumah dan tujuan komersial. Bahagian utama dalam kajian ini adalah untuk membela ikan tilapia merah, menanam sayur, dan pokok strawberry. Kajian ini memfokuskan kepada demonstrasi tanaman menegak iaitu sebagai jalan penyelesaian kepada masalah alam sekitar dan kekurangan makanan sihat. Kaedah moden ini akan meningkatkan pengeluaran makanan, membekalkam makanan, dan mengurangkan kesan negative kepada alam sekitar. Ini melibatkan proses merekacipta dan menyiapkan rumah aquafonik berserta sistemnya sekali. Sayuran ditanam di dalam bekas yang dimasukkan kedalam lubang diatas paip manakala ikan ditempatkan didalam tangki ikan. Selain daripada itu, tanaman juga akan ditanam di dalam tempat tanaman yang diperbuat dari gentian fiber yang diletakkan lebih tinggi daripada tangki ikan. Air daripada tangki ikan akan di pam ke dalam tempat tanaman untuk membekalkan sumber oxigen kepada tanaman. Air tersebut akan ditapis secara semulajadi dan mengalir kembali ke tangki ikan. Reka bentuk paip yang mempunyai tujuh lubang disetiap batang paip telah disusun diatas paip tersebut. Air daripada pam akan mengalir pada kadar 1.2408×10^{-3} m^3 /s. selain itu, dua buah tangki berbentuk lengkung akan ditempatkan di dalam rumah aquafonic dan menggunakan system tanaman jenis poliseren yang terapung di dalam setiap tangki tersebut. Tangki tersebut diperbuat daripada gentian fiber juga telah diperkukuhkan rekaannya. Analisis ketahanan terhadap tangki tersebut akan dilakukan untuk membandingkan sebelum dan selepas proses pengukuhan. Hasil daripada analisis menunjukkan struktur binaan tangki tersebut telah ditingkatkan. Akhir sekali, system tersebut telah lengkap dan dipasang.

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ρ	Density
g	Gravity
s	Second
m	Meter
mm	Milimeter
v	Velocity
t	Time
V	Volume
L	Litre
H	Hour
D	Diameter
N	Newton
A	Area
Q	Volume flow rate
P	Pressure

LIST OF ABBREVIATIONS

3-D	3-Dimensional
PVC	Polyvinyl chloride
MAX	Maximum
MIN	Minimum
MIG	Metal Inert Gas
AW	Arcs welding

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Aquaphonics is the combination of aquaculture and hydroponics. In aquaphonics, we rear fish and plants together in one integrated, soilless system. The fish waste provides a food source for the plants and the plants provide a natural filter for the water the fish live in. Aquaphonics produces safe, fresh, organic fish and vegetables. When aquaphonics is combined with a controlled environment greenhouse, quality crops can be grown for few months, everywhere in our country. Aquaphonics can be used to sustainably raise fresh fish and vegetables for a family, to feed a village or can give income in a commercial farming field.

Vertical farming is planting vegetable on pipe with water from fish tank. The plants are grown at different level such that the water will flow down from top to bottom and back to the fish tank. We can produce about twice the amount of plants as we can with an ordinary agriculture land system of the same area. The system used fish waste to work as fertilizer for crops.

A small pump powered by PV panel with dc motor will be install to draw water from the fish tank to the tops of the vertical columns then the gravity will flow the water down through the roots of the plants. It releases almost no waste and, because it is soil free, there is no need for fertilize. If we do it right, we do not have to clean the fish tank. We may have to replace some lost water as needed. It might not be too hard to power one of these pumps with a small solar panel or some other renewable energy.

1.2 PROBLEM STATEMENT

Nowadays, rapid development of country gives an effect to agriculture because land of agriculture was destroyed in order to make new building and residential area. Vertical hydroponics provides an intelligent solution to gardeners that have limited horizontal space and for gardeners that want to maximize their yield. They are mostly suited to that do not grow very tall, and can be used effectively on walls, fences, balconies, and for higher density growth in small yards. The usage of chemical pesticide can be dangerous for the people. It possibly avoided when we practice aquaphonic system. The advantages of this method of farming can be further exploited by large scale production of crops. The controlled growing conditions will reduce the use of chemical pesticide

1.2 OBJECTIVE OF THE STUDY

The purpose of this research is to design and fabricate a vertical farming aquaphonic system for green house application.

1.4 SCOPE OF STUDY

The scope of study is to rear red tilapia fish, vegetable and strawberry plants.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the literature review of previous research that has been conducted in many countries will be review. It will include the basic knowledge about vertical soilless farming, aquaphonic and hydroponic. Many researchers have investigated the method how to create system that can be practice for all people and it is possible to achieve it.

2.2 SOILESS FARMING

For many years, human beings have fed themselves by growing a huge variety of vegetables and grains. In more recent years, technology has helped increase harvests, shorten growing time, and make growing crops indoors feasible. Genetic engineering has brought about strains of plants that are resistant to many diseases. These plants also grow more quickly and spoil also become less. Indoor farming helps to lengthen the growing season and reduce the effect of weather on crops. Now, there is another way of growing the food the world needs. According to Despommier (2009), food production increases, the effects of global warming decrease, the production of clean-burning fuel increases and waste water is made cleaner by creating vertical farms. He was concerned with the fact that the world's population will increase to nearly 9 billion by 2050. He also is concerned that nearly 80% of the world's suitable farming land is already in use. With current farming methods it would take an area larger than the country of Brazil to create enough food to feed the population of nearly three billion additional people by the year 2050.

Realizing that current farming methods will not be adequate in the future, Despommier (2009), has thought about taking current indoor farming methods several steps further. He has explored the concept of vertical farming using multi-storied buildings and tiers of planters to grow a variety of crops. He envisions skyscrapers in the middle of large cities providing fresh vegetable for the entire city. There are many advantages of this idea such as:

First, indoor farming will produce crops that are more productive since plants will not be affected by changes in climate or by rain, hurricanes, floods, monsoons, ice or droughts. In addition, the food grown will be used quickly and consumed by local people, so the damage will be at a minimum. Land in vertical farming also will be used more productively than before it was introduced. Depending on the type of crop grown, an indoor farm can produce as much food as four to six acres of outdoor farming, without the huge losses that outdoor farming can sustain. With vertical farming, crops can be grown more frequent within a year.

Second, vertical farming will make crops grow organically in more simple way and less expensive. Since plants will grow indoors, pesticides will not be needed to protect plants from insects. In addition, fertilizers would not be needed because the indoor methods will provide enough nutrients for plants without having chemicals addition.

Third, this new type of farming will greatly decrease the chances of spreading infectious diseases such as rabies, West Nile virus, malaria and salmonella. Currently, many of these diseases are transferred to food by wild animals and by farm animals that have grazed where the food is being grown. (Despommier, 2009)

Another significant advantage of vertical farming is those current farmlands will maintain to its original purpose. Forests and jungle will begin to be preserved in areas that were used for farming, returning the ecosystems to their natural states. The world’s supply of oxygen will increase, helping to protect the ozone layer. Chris Jacobs, working with Dr. Despommier, has created a number of innovative designs. One of the designs is based on the Capitol Records building in Hollywood, California.

Using the same type of round design, Jacob’s creation uses space more effectively than square or rectangular buildings. His design covers large area of glass and a rotating solar panel at the top to absorb the sun’s energy. Wind power is also used to provide energy for the many functions of the buildings. The concept of vertical farming is beginning to catch on around the world.

Aquaphonic is a way of plant agriculture that combines hydroponics and aquaculture. The wastes produced by fish are absorbed by the plants as nutrients and filter the water to prevent water toxification that harms aquatic animal (Kumar, Beria, Garber, Neu, Sebes & Sheetz, 2006). This cycle support the existence of both the plants and fish. The idea of aquaponics was taken from the ancient farming techniques, wherein the nutrients in nature were recycles. The reason for the definitions is because aquaphonics is a mixture of aquaculture and hydroponics.

It is the same concept as hydroponics. The plants roots are submerged in the water with the fish waste and ammonia that are added is the part of the system that is like aquaculture. The plants absorb and suck up all the ammonia and turn them into nitrites and then into nitrogen, which then helps the plant because the plant needs nitrogen in order to live.

The aquaphonic system consists of two main parts the reservoir and the grow bed. The reservoir holds the fish and the grow bed hold the plants. It works by using a pump that takes the water up to the grow bed from the reservoir and waters the plants as well as giving them nutrients from the fish such as ammonia.

Aquaphonic is important because it helps during food shortage. It also gives you organic fruits or vegetables. Usually you will not need to put chemicals into your aquaphonic system because the plants absorb the ammonia not killing the fish. The only chemicals needed for an aquaphonic system is iron which helps give the plants more nutrients and it also does not harm the fish

2.3 HYDROPONIC

Hydroponics is the science of growing plants in a soil-less medium. The roots feed on a nutrient rich solution that contains all the essential elements necessary for the normal plant growth and development. Plants grown hydroponically are not physiologically different than plants grown in soil. Both inorganic and organic components need to be decomposed into inorganic elements in order to become available for plant uptake (Carpenter, 1994). However the plant processes involved in obtaining minerals from a soil solution compared to a hydroponic solution are different. Mineral nutrients become available for plant uptake when soil colloids release minerals into the soil solution through solubilization of soil minerals and organic matter (Resh, 1995). In hydroponic culture dissolved nutrients are delivered to the plant in a solution rather than a soil solution. Therefore hydroponics allows maintaining the plant in an ideal nutrient condition.

However, the margin of error is great due to the lack of buffering capacity, which can result in plant starvation or nutritional stress. Hydroponics is an efficient and profitable technology for growing plants. Hydroponics is a valuable means of growing plants in regions with little arable land or regions with large, dense populations (Schoenstein, 1996). Hydroponic culture allows for increases in density spacing and yields due to minimal competition among roots. For example, hydroponic organic basil production in California spaced their plants at 12.7 cm centers (Schoenstein, 1996). Herbs have the potential to grow up to 25 percent faster in a hydroponic solution compared to soil (Skagg, 1996). Plants grown hydroponically have a threefold increase in vitamins and minerals compared to plants grown in soil (Skagg, 1996). By the year 2000, Dutch growers will more than likely be totally free of soil (Carpenter. 1994).

2.4 FISH FARMING

2.4.1 Red tilapia

There are about 70 species of tilapias, most of them native to Western rivers of Africa (Anon, 1984). According to Food and Agriculture Organization in 2002 (FAO 2002) from 70, only a few of species are used in commercial and as food such as Nile tilapia (Oreochromis niloticus), Mozambique tilapia (Oreochromis mossambicus) and Blue tilapia (Oreochromis aureus). The term of Red tilapia is widely used since it more familiar at every place we go to find the fresh fish. As we know, Red tilapia is not origin of tilapia species, but it is the name used to describe different type of tilapia that has variant attractive red color. They are result of continuous selected breeding.

Statistic from FAO (2002) shows that among of that species, the most well-known species is Oreochromis niloticus since it has been reason for the increasing in tilapia production from fresh water aquaculture and accounted for about 83% of total tilapias produced worldwide. (Pullin, 1983) has make comparison between various tilapia species with culture potential and give suggestion to be concentrated on Oreochromis niloticus and Oreochromis aureus.

Shelton (2002) has claimed that Oreochromis niloticus is higher production compared to the hybrids species. This species is the most favored by farmers due to its suitability for farming in a wide field of culture environments, higher demand, and give more productivity at low cost. The other species that are gaining recognition because of their adaptability to certain conditions are Oreochromis aureus for colder waters and Oreochromis spilurus for saline waters or water that have amount of dissolved salt.

Red tilapia hybrid was produced for the first time in Taiwan through combination of two species that are Oreochromis mossambicus and Oreochromis niloticus then the third generation of tilapias. It is the combination favored colors with other desirable features of tilapias (Anon, 1994).

This fish has gained increasing preference of commercial farmers in some countries because of their reddish color liked by consumer. In terms of performance, (Alceste, 2000) claimed that Red tilapias are suitable for seawater culture because of salinity tolerance of the parental species, known to be moderately (Oreochromi niloticus and Oreochromis aureus). Red tilapia hybrids are most commonly used in aquaculture operations because they have potential for culture since it is easy to look after.

CHAPTER 3

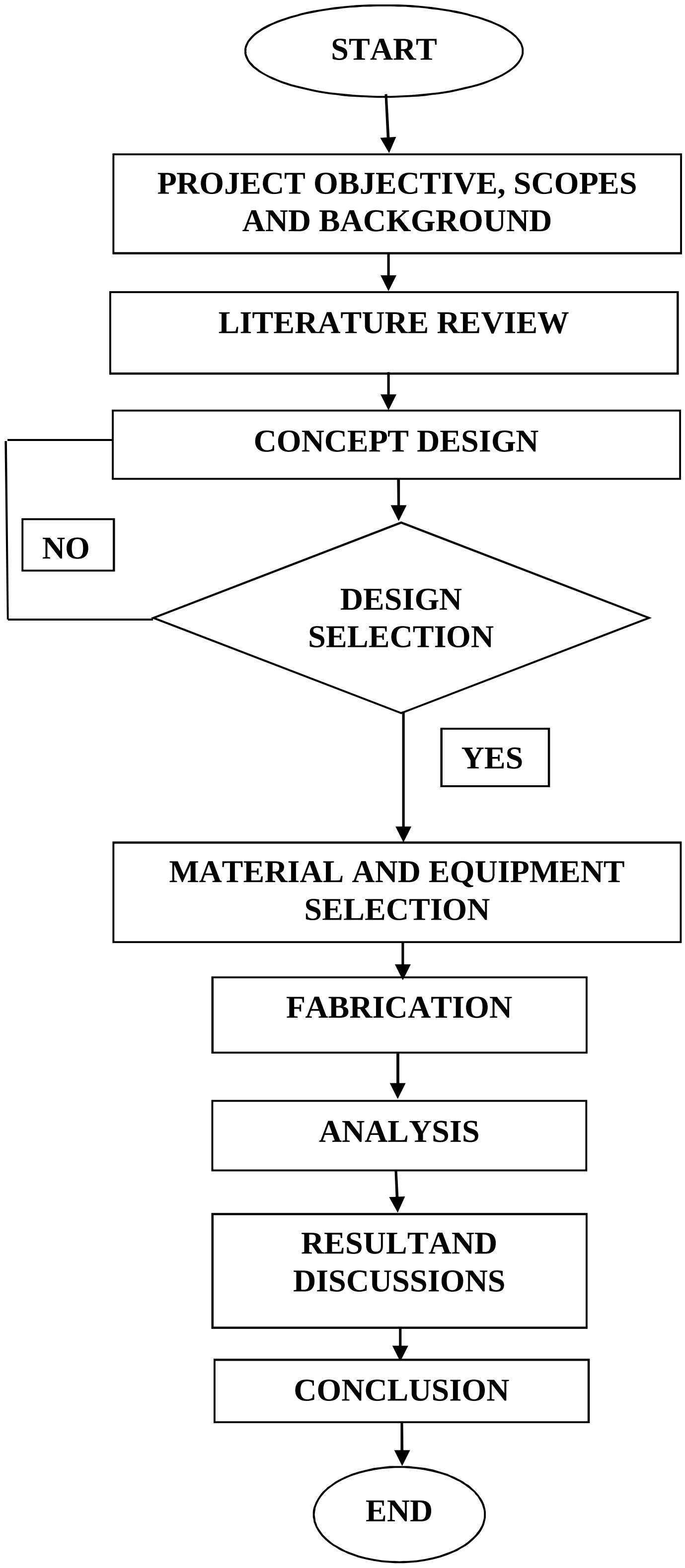
RESEARCH METHODOLOGY

3.1 INTRODUCTION

The goal of my project was to design and fabricate a vertical soilless farming aquaphonic system for home and commercial application. Flow chart will be used to give a clear process flow from the beginning until the end work. In this research methodology, the design process will be done in a 3D model by using Solidworks software, and then will be proceed to material and equipment selection.

This project begins with the determination of the project objectives, scopes, background and also literature reviews on previous research that has been conducted in many countries After doing the literature review, the designing of the fish tank and aquaphonic house will be carried out and after the final design was decided, the material and equipment that will be used in the fabrication process is selected. The result of the fabrication will be discussed further in Chapter 4.

3.2 FLOWCHART



3.3 CONCEPT DESIGN

Vertical farming does not have much different in design compared to ordinary gardens. They need vessels to grow plants, most commonly pots that are pipes, a nutrient reservoir, nutrient solution, watering system, fluid lines, and a pump. Because of their increased height compared to ordinary gardens, vertical farming need pumps that can deliver greater pressure, so as to be able to deliver nutrients to the top of the garden along with sufficient pressure to spray the nutrients onto the plants. Vertical farming can also be grown indoors as home application at every house.

3.3.1 Fish tank

The function of the fish tank is not only to keep fish but also acts as water storage and supply water for the vegetables. Figure 3.1 shows the first concept design for the fish tanks including the pipes containing pot holes, supporting rods, and also water pump. The size of the fish tank must be big enough to provide larger space for the system. The components such as vegetable pots, smaller pipe line, and the supporting rods will be placed above the fish tank, while the water pump and the red tilapia will be place inside the tank as shown in Figure 3.1.

The vegetable is place inside the pot holes on the pipe. At the end of the pipe, there will be a smaller pipe which is to flow the water back into fish tank. Water must move around the system for it to be a complete system. This is normally done with a submersible water pump. We must also make sure the water can flow back to the rest of the system by choosing the right size of plumbing.

This concept design was chosen as the final design because it is easier to be fabricated compared to the second concept design which was shown in Figure 3.3. Other than that, the design of the piping system is more stable and provides larger space for the plantation of vegetables compared to the second concept design.

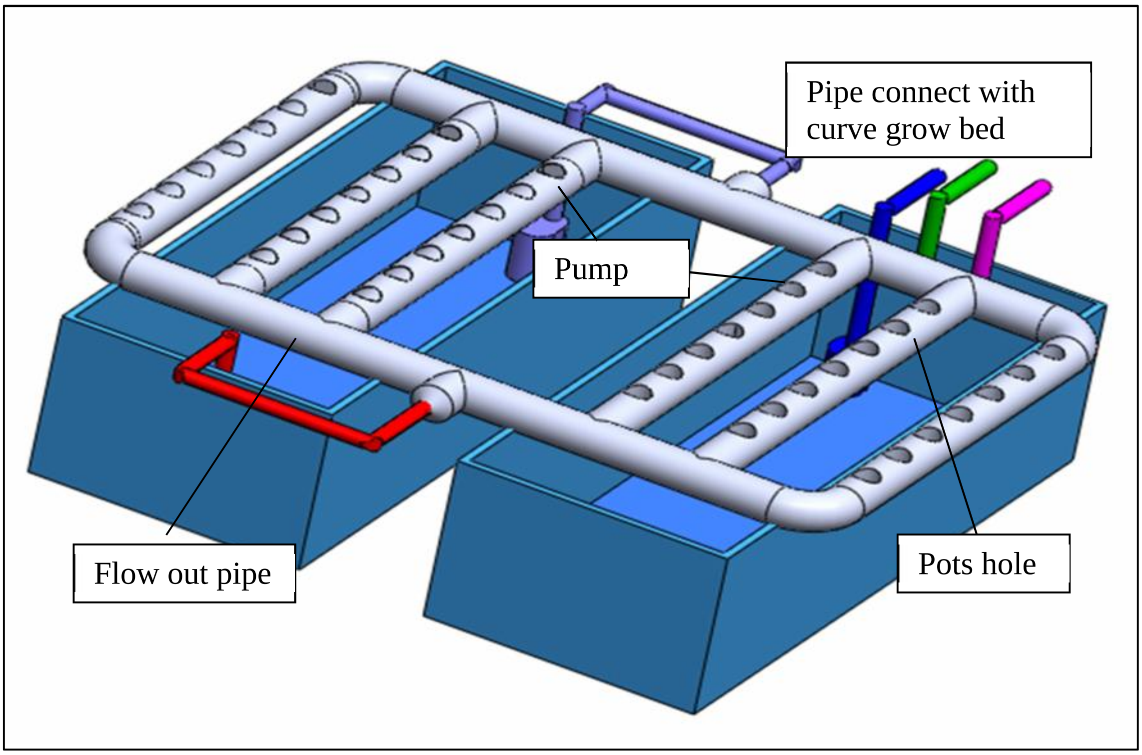


Figure 3.1 : concept design 1

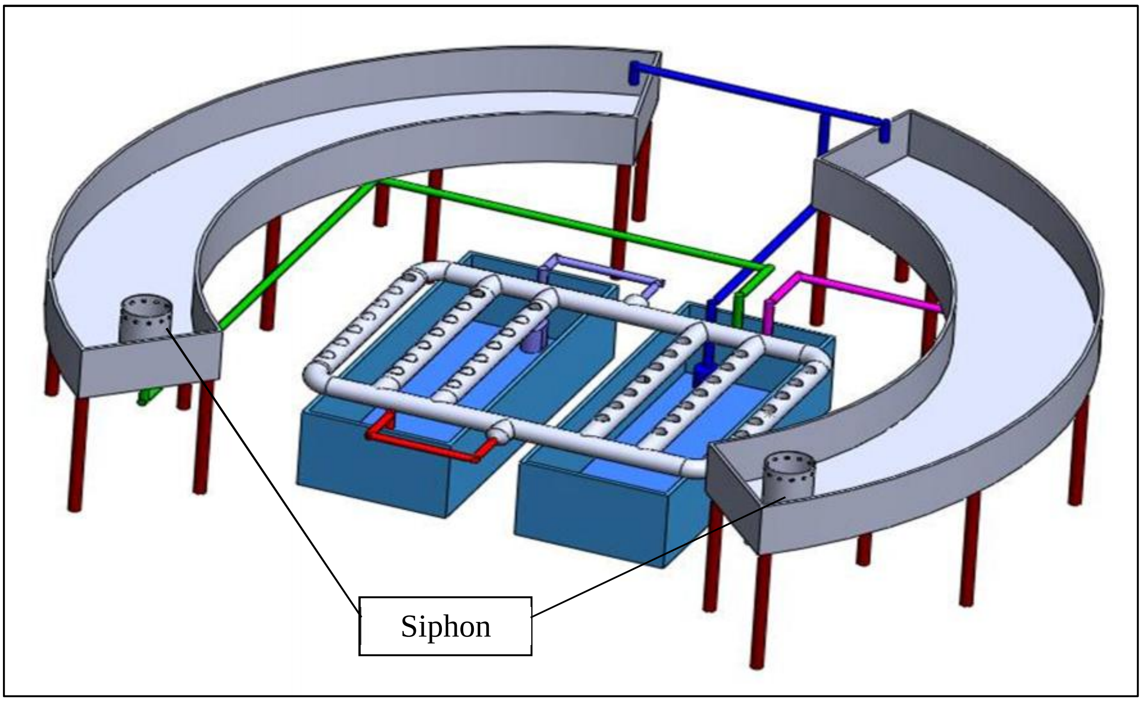


Figure 3.2: Overall concept design 1

Figure 3.3 shows the second concept design, where the difference is that the pipes containing holes is arranged vertically above the fish tank. The figure also shows the fish tank design including the pipe containing pot holes, supporting rods, and also water pump. The size of the fish tank must be big enough to provide larger space for the system. Same as in the first concept design, the components such as, vegetable pots, and the supporting rods will be placed above the fish tank, while the water pump and the red tilapia will be place inside the tank as shown in Figure 3.3.

The pipes containing holes, which is where the vegetables will be planted was arranged vertically so that the water will automatically flow back down to the fish tank and all vegetables will get the water supply which was pumped up from the fish tank by using the water pump. Compare to the first concept design, this piping system is harder to fabricate and also less stable than the first concept design. The space provided for the plantation of vegetable is also less compare to the first design concept.

The overall design of the fish tank that will be placed inside the aquaphonic house can be seen in Figure 3.4. There will be an aquaphonic curve tank located above the fish tank. The function of the curve tank is to provide an extra space to plant the vegetables. Water from the fish tank will be pumped up to this tank and there’s a pipe that will supply the pumped water to the vegetable inside the curve tank. The specific dimension of the curve tank was shown in Figure 3.5.

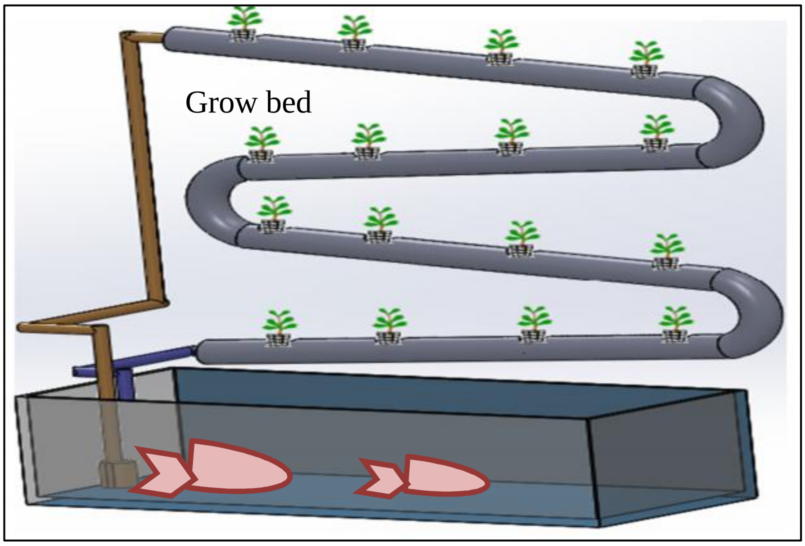


Figure 3.3: Concept design 2